NASA TECH BRIEF

One-Dimensional Two-Phase Reacting Gas Nonequilibrium Performance Program

The problem:

To develop a one-dimensional method for calculating the equilibrium, frozen, and kinetic performance of systems having gaseous and condensed exhaust products containing the elements carbon, hydrogen, oxygen, nitrogen, fluorine, and chlorine; and one metal element, either aluminum, beryllium, boron or lithium.

The solution:

A computer program which calculates the inviscid one-dimensional equilibrium, frozen, and nonequilibrium nozzle expansion of propellant exhaust mixtures containing the above six elements plus the selected metal element.

How it's done:

The computer program considers all significant gaseous species present in the exhaust mixtures of propellants containing the above elements and all gas phase chemical reactions which can occur between the exhaust products. The program also considers the velocity and thermal lags (for five particle groups) between the gaseous and condensed combustion products (when they are present in the chamber). The program does not consider mass transfer, except in the equilibrium option, between gaseous and condensed combustion products. In order to reduce the computation time per case to a minimum, the program uses a second order implicit integration method. This integration method has been demonstrated to reduce the computation time per case several orders of magnitude when directly compared with the computation times required using standard explicit methods such as fourth order Runge–Kutta or Adams–Moulton methods.

This program is completely self-contained, requiring specification of only the propellant system (elemental composition and heat of formation), relaxation rates, and nozzle geometry to run a case. The chemical species considered have been selected to allow accurate equilibrium, frozen, and kinetic performance analyses of cryogenic, space storable, prepackaged, hybrid and solid propellant systems of current and projected operational use. This program allows analysis of the performance loss associated with film cooling in propellant systems having all gaseous exhaust products. It also allows simultaneous consideration of both chemical and gas-particle relaxation losses in propellant systems having condensed exhaust products. The program is designed for engineering use and is specified and programmed in a straightforward manner to facilitate its use as a development tool.

Notes:

1. This program is written in Fortran IV for use on the IBM 7094 computer.
2. This program will perform calculations for conical nozzles only.
3. Related computer programs are described in NASA Tech Briefs 68-10374, 68-10375, and 68-10377.
4. Inquiries concerning this program may be made to:

   COSMIC
   Computer Center
   University of Georgia
   Athens, Georgia 30601
   Reference: B68-10376

(continued overleaf)

Patent status:

No patent action is contemplated by NASA.

Source: J. R. Kliegel, V. Quan, S. S. Cherry, and H. M. Frey of TRW Systems under contract to Manned Spacecraft Center (MSC-11780)